

Designing for a pandemic: towards recovery and resilience

MULLAGH, Louise, COOPER, Rachel, THOMAS, Lisa, SACKS, Justin, JONES, Peter Lloyd and JACOBS, Naomi

Available from Sheffield Hallam University Research Archive (SHURA) at:

<http://shura.shu.ac.uk/28474/>

This document is the author deposited version. You are advised to consult the publisher's version if you wish to cite from it.

Published version

MULLAGH, Louise, COOPER, Rachel, THOMAS, Lisa, SACKS, Justin, JONES, Peter Lloyd and JACOBS, Naomi (2021). Designing for a pandemic: towards recovery and resilience. Strategic Design Research Journal, 14 (1), 161-174.

Copyright and re-use policy

See <http://shura.shu.ac.uk/information.html>

Designing for a pandemic: towards recovery and resilience

Louise Mullagh ^a* | Rachel Cooper ^a | Lisa Thomas ^a | Justin Sacks ^a
Naomi Jacobs ^a | Peter Lloyd Jones ^b

^a Lancaster University, ImaginationLancaster: Lancaster, United Kingdom.

^b Sheffield Hallam University, Lab4Living: Sheffield, United Kingdom.

* Corresponding author: l.mullagh@lancaster.ac.uk

ABSTRACT

Design is recognized as a discipline that is ideally placed to work across boundaries to tackle wicked problems and help cope with uncertainty. As humanity continues to become more interconnected it is thought that we are becoming more exposed to viruses such as COVID-19. Therefore, the current pandemic offers us opportunities to re-think and re-design many of our practices to ensure we are resilient in future similar crises. Through the creation and analysis of a database that captures design interventions that have emerged during the pandemic, the paper considers the role design can play in collectively recovering from the current pandemic and building resilience for the future. Whilst the findings represent the beginning of this process, (from late March until June 2020) we find that design has been deployed in a wide range of ways and on all scales, from the personal, communal, organizational, national and international. However, as we live through and emerge from the pandemic we should reflect, within the realm of design research and beyond, on how we might harness design to enable recovery and build resilience for the future.

Keywords: Design for Pandemics, Design Research, Recovery and Resilience

INTRODUCTION

In late 2019 an outbreak of the virus SARS-CoV-2, (COVID-19) was recorded in China (WHO, 2020). By December 2020, the World Health Organisation (WHO) stated that there had been more than 79 million confirmed cases and 1.7 million deaths (WHO, 2020). In the summer of 2020 cases in the UK were falling, with local outbreaks being managed through lockdown and medical treatment measures. In other countries, including China, Germany and South Korea, new outbreaks emerged in response to eased lockdown measures and were being managed through re-introduction of stricter measures. Despite these hyper-local, regional and national initiatives, worldwide rates of infection and mortality continued to increase, notably in the UK, US, India and Brazil. In late 2020, second waves hit, and the UK introduced a new tier system to mitigate regional outbreaks. When this tier system was demonstrated to have been unsuccessful in stopping the rise in cases, national lockdowns were enforced in November. Lockdowns were enforced again in January due to a rapid increase in cases and the identification of a new variant (VUI-202012/01) which has been thought to result in the virus becoming more infectious (BMJ, 2020). On December 8th, 2020 the first vaccine in England was administered, marking a significant step towards controlling the outbreak.

As we wait to discover the efficacy of bioengineered and/or pharmacological treatments aimed at preventing or treating COVID-19, we remain highly susceptible to the virus. In the meantime, complex behaviours are being encouraged or mandated as the means for allowing us to emerge from the lockdown towards recovery and a more certain state of being. Even so, our home, social and working lives exist in a state of limbo, at least for the foreseeable future.

This paper explores the following research question:

What role can design play in the recovery from COVID-19 and in building resilience for future pandemics and global emergencies?

In this paper we explore how design has been deployed around the world to harness creativity and innovation, across disciplines and often across borders, to develop solutions to the highly complex problems the pandemic has highlighted.

1. DESIGNING FOR AND IN A PANDEMIC

There have been pandemics throughout history that have re-shaped our social and physical environments (Budds, 2020), having profound effects upon urban design and infrastructure to create healthier towns and cities. This pandemic is no different in that respect, as we need to tackle issues such as living in high-density cities and un-equitable access to technologies.

It is clear that recovery is essential. But once we have a form of stability, there is also a need to develop resilience: that is, the capacity to adapt and thrive in uncertain conditions (Meyer, 1982). To understand how design interventions have matured throughout the pandemic around the world four stages were identified: reaction, adaptation, recovery and resilience.

1. Reaction: Countries impose lockdowns or strict track and trace systems due to rising cases. New laws are rapidly passed and the economy essentially shuts down.
2. Adaptation: Systems begin to adapt and society becomes used to the 'new normal'. Adapting to new measures such as social distancing. Finding new ways of connecting socially and working remotely.
3. Recovery: Emerging from lockdown, where social distancing is still required but many industries return to work and schools re-open, with localised lockdowns enforced due to small breakouts. The economy begins to recover.
4. Resilience: Lockdown measures eased and social distancing relaxed to pre-pandemic state. Time to reflect and investigate key issues and understand what we can learn personally, socially, economically and globally, and to inform new ways of building human and planetary wellbeing.

2. DESIGNING FOR AND IN PANDEMICS: A DATABASE

This section presents key findings extracted from our database from each of the design categories, which are split into the first two stages of *Reaction* and *Adaptation*. From the database of over 130 examples, we present key examples to illustrate how designs mature throughout the pandemic and consider how design might be used in the following stages.

Following this, we present some examples categorized in the *Recovery* and *Resilience* stages, which are those which we feel can be developed to create more mature design interventions that can be utilized in the near and further future.

2.1. TECHNOLOGY DESIGN AND USE

Stage 1 Reaction:

The rush to design and implement technologies in tracking the virus to limit its spread was seen worldwide (Ada Lovelace, 2020). Many of the designs for mobile applications and wearables to track citizens or the use of AI and IoT did not take fully into account issues such as privacy, data protection or ethics by design, an area that has received significant attention in various areas of design research in recent years (Lindley et al 2018; Veale et al, 2018).

Contact tracing mobile applications: The use of mobile applications to trace contacts and alert those who might be at risk of contracting the virus has been seen as a key tool in the fight against the pandemic and a key enabler to governments in re-opening their economies (Ada Lovelace, 2020). We tracked a range of applications from the initial *React* stage, through to the *Adaptation* stage to understand their design and implementation. At the time of writing more than 30 public and private systems were being developed or in use around the world.

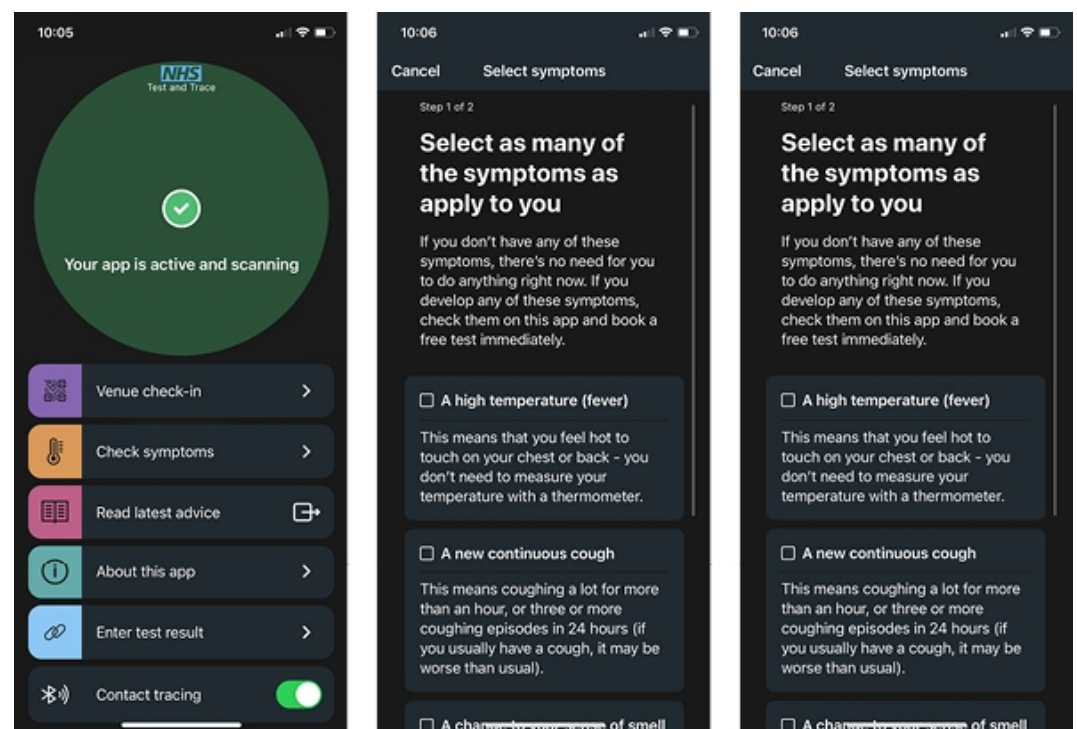


Figure 1. NHS England COVID app

We found significant variation in the speed at which they were designed and deployed. The earliest countries to be exposed to the virus implemented a range of solutions, from private and government apps in South Korea, the use of QR in China, TraceTogether in Singapore (TraceTo) and the StayHomeSafe app in Hong Kong. However, the use of mobile applications to combat the spread of a virus such as COVID-19 relies upon a high percentage of the population downloading the app and this requires a level of trust from the population.

In recent years issues relating to data security and privacy by design have been explored in areas of design research (Lindley et al, 2018); however we have found that the current urgency to develop these tools has led to too much reliance upon their implementation alone (Ada Lovelace Institute, 2020; Morley et al, 2020; Stokel-Walker, 2020). At this early stage we see the lack of consideration of not only usability and access to mobile technologies but the lack of designing ethics and privacy into the applications (Ada Lovelace Institute, 2020; Morley et al 2020).

Drones: The use of drones during the pandemic has largely been focused on delivery of supplies to those self-isolating and to hospitals, and as a mode of surveillance to ensure social distancing and isolation measures are adhered to. Existing drones have been re-purposed with new software and have been subject to revised airspace regulations (in America) to enable operators to carry out their new roles. America and China have been the key sites of drone use during the pandemic. It is not necessarily the design of the drone itself we ought to consider in light of their use during epidemics, but the infrastructure and practices they are embedded within and the impact upon the populations for which they are operating, in particular issues of surveillance and privacy.

In China drones have been deployed to aid in disease detection and crowd management, using thermal sensors, high-definition zoom lenses, loudspeakers and chemical spray jets to disinfect large areas (Liu, 2020). Through re-designing the application of the drones, it is hoped that less human contact will be had and the virus would not spread as quickly. However, this raises issues around privacy and the use of drones in surveillance. Similar drones were banned in France as they were deemed to constitute serious privacy infringements (Fouquet and Sebag, 2020). In America drones have been deployed to deliver groceries for those who are self-isolating, with Google's parent company Alphabet Inc deploying their machines that can make deliveries without having contact with customers (Block, 2020).

Whilst drones present opportunities for non-contact delivery, surveillance and large-scale disinfecting, it is important to remember that they often operate in environments that have not been designed for them (Cureton, 2020a). If drones become more commonplace the design of the built environment will need to be re-considered. Longer term use will require adaptations such as landing pads, adequate charging facilities and landscaping to mitigate noise emissions (Cureton, 2020b).

Robots: Robots have been deployed in settings such as hospitals and public parks. All of the examples included in the database are existing systems re-purposed for carrying out new tasks, as this enabled rapid deployment and ease of use by their operators. As with the issues we identified (above) with contact tracing apps and drone use, the deployment of robots also needs ethics carefully designed into their use.



Figure 2. Robot in operating theatre (courtesy of UVD Robot®)

In Singapore and China dog robots designed and produced by Boston Dynamics were deployed to ensure social distancing was adhered to in parks. The robots feature cameras

and speakers, enabling operators to view the park and communicate with visitors (Neira, 2020). In hospitals robots have been deployed to ensure cleaning could be carried out without the need for people, which enabled the disinfection of patient rooms and operating theatres (Ackerman, 2020). We also found examples of robots being designed to provide contact-free support in a variety of healthcare roles, from carrying out basic monitoring and testing in hospitals, to providing remote care for vulnerable patients or those diagnosed with the virus (Spears, 2020). However, issues remain around the need to provide face to face care for vulnerable patients, which should be considered as part of a human-centred approach for the holistic implementation of technologies within healthcare settings.

Stage 2 Adaptation: As we moved into the adaptation phase, the use of mobile tracing apps, drones and robots continued. The use of wearable devices, in particular fitness trackers in the form of bracelets and watches began to develop as governments and private developers started to explore their potential in tracking the health of citizens (Venkataramakrishnan, 2020).

We found examples using existing technologies such as Fitbit and the Apple watch as an early warning system to monitor signs such as heartbeat before the symptoms occur. South Korea utilized the 'Safe Korea' bracelet to enforce quarantine rules after people were caught leaving the house without their smartphones to avoid detection (BBCb, 2020). Bracelets and bands have been designed and deployed across the world including Hong Kong, Lichtenstein, and Belgium (Privacy International, 2020; BBCb 2020; Comarch, 2020).

While wearable devices offer a passive experience and can be produced relatively inexpensively (such as South Korea and Belgium's examples) they once again pose potential issues of data creep, where more data than originally intended can be collected and their use can be enforced post-pandemic (Privacy International, 2020).

2.2. GRAPHIC DESIGN AND COMMUNICATION

Stage 1 Reaction: Clear communication has been vital during all stages of the pandemic thus far, but particularly so in the early stages as governments rushed to roll out social distancing guidance and the processes entailed in track and trace systems.

Government communications: The new situation had the potential to cause widespread panic or misunderstanding of the rules. During times of stress clear communication is vital and governments had to design and deliver information and messages accurately with as little room for misinterpretation as possible (Dixon, quoted in Wong 2020b). The information communicated by governments evolved rapidly and was disseminated through multiple online and analogue channels. Clear and simple typography, colour and images were key in delivering unambiguous messages, as was demonstrated by the New Zealand Government in their 'Unite Against COVID-19' campaign (New Zealand Government, 2020). In the UK the government were criticized for a lack of coherence in their messaging and imagery, demonstrating how designing campaigns rapidly and under pressure can directly impact the public's perception and understanding of key communications (Moore, 2020).

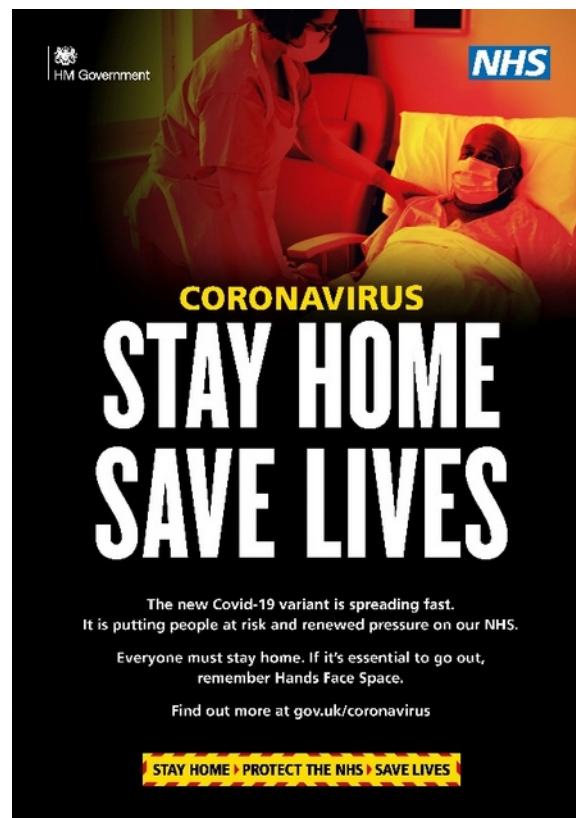


Figure 3. Public Health England COVID poster (UK Government, 2020)

The use of 'Stay home, protect the NHS, save lives' in the first stage follows the rule of three often adopted in campaigns. The 'Stay home ...' image was coloured red with chevrons to denote the severity of the situation (Ivey-Williams et al, 2020) and communicate clearly what was expected of the public. During the easing of the lock-down in May the messaging changed to 'Stay alert, protect the NHS, save lives', and the red changed to green, which was criticized for being less clear, due to the association of green with 'go'.



Figure 4. New Zealand Government health poster (New Zealand Government, 2020)

Public health: In April the World Health Organisation (WHO) launched a competition – ‘Global Call out to Creatives’ (WHO, 2020b). The aim was to translate public health messages such as the importance of hand washing, sneezing and coughing into tissues and physical distancing into clear messages through the use of creative design. The submissions were all made available on the WHO platform to be used in any kind of campaign and designers consented to the open use of their work on submission. This is an example of how design can be harnessed to communicate across cultures, and the keenness of designers to become involved in global campaigns.

Stage 2 Adaptation: Design continues to play a vital role in communicating messages. One key image that has been consistent throughout the pandemic is that of the virus itself. The image has become widely used and shared globally, after its release by the Centres for Disease Control and Prevention (CDC) in America. The CDC felt the virus should be given an identity to be able to communicate the risk and make something that seemed so abstract into a tangible entity. Designers wanted to create ‘a realistic virus that people can envision when walking into public places or coming into close contact with strangers’ (CDC, 2020). This image has been adapted countless times during the pandemic and is now recognized as short-hand for COVID-19.

2.3. DATA VISUALIZATION

Stage 1 Reaction and Stage 2 adaptation: Throughout the pandemic data visualizations have become a vital method of communication around the world (Kennedy, 2020) to communicate the spread of the disease and death rates. Whilst charts, graphs and infographics have become essential in providing vital information, there are issues relating to literacy, of being able to understand visualizations and the bias that resides in the choices of data made and the accuracy of data (Kennedy, 2020).

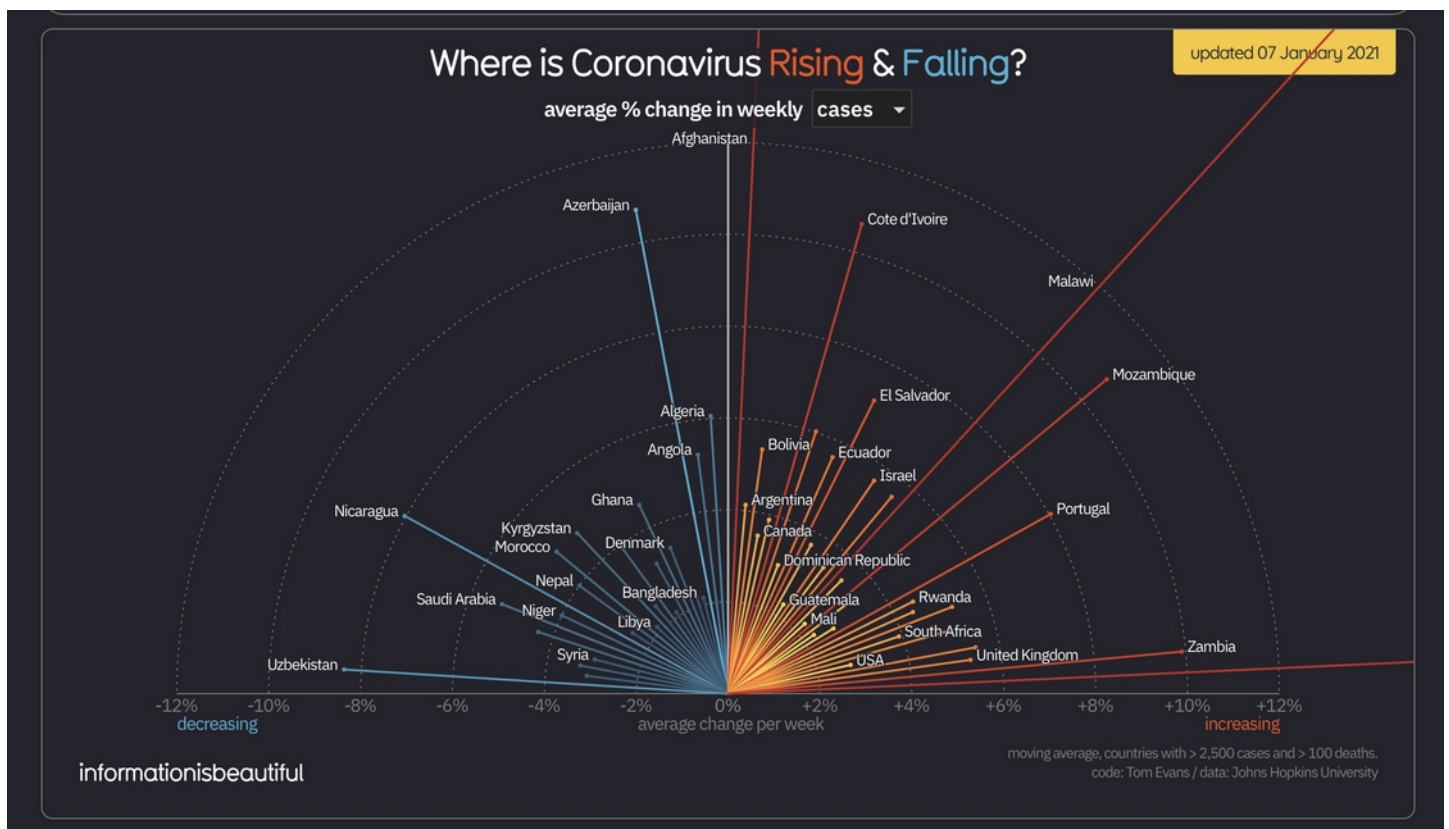


Figure 5. “Where is coronavirus rising and falling” graphic from Information is Beautiful website (Information is Beautiful, 2020)

The Information is Beautiful website, (McCandless, 2020) has become a benchmark in creating data visualization. The site hosts a wide range of COVID-19 related infographics and visualizations that are interactive and present a variety of data from around the world. Perhaps the most trusted source of data and visualizations during the pandemic has been the Johns Hopkins data repository (Johns Hopkins, 2020). In the UK a data dashboard has been developed by the Government where the 'raw' data can be downloaded and used. As experts in global public health and infectious diseases they have been a source of data and information that is widely trusted. The danger in presenting highly aestheticized visualizations of such complex data, as we see on many web-based platforms, is that it presents a particular view of the world (Kennedy, 2020).

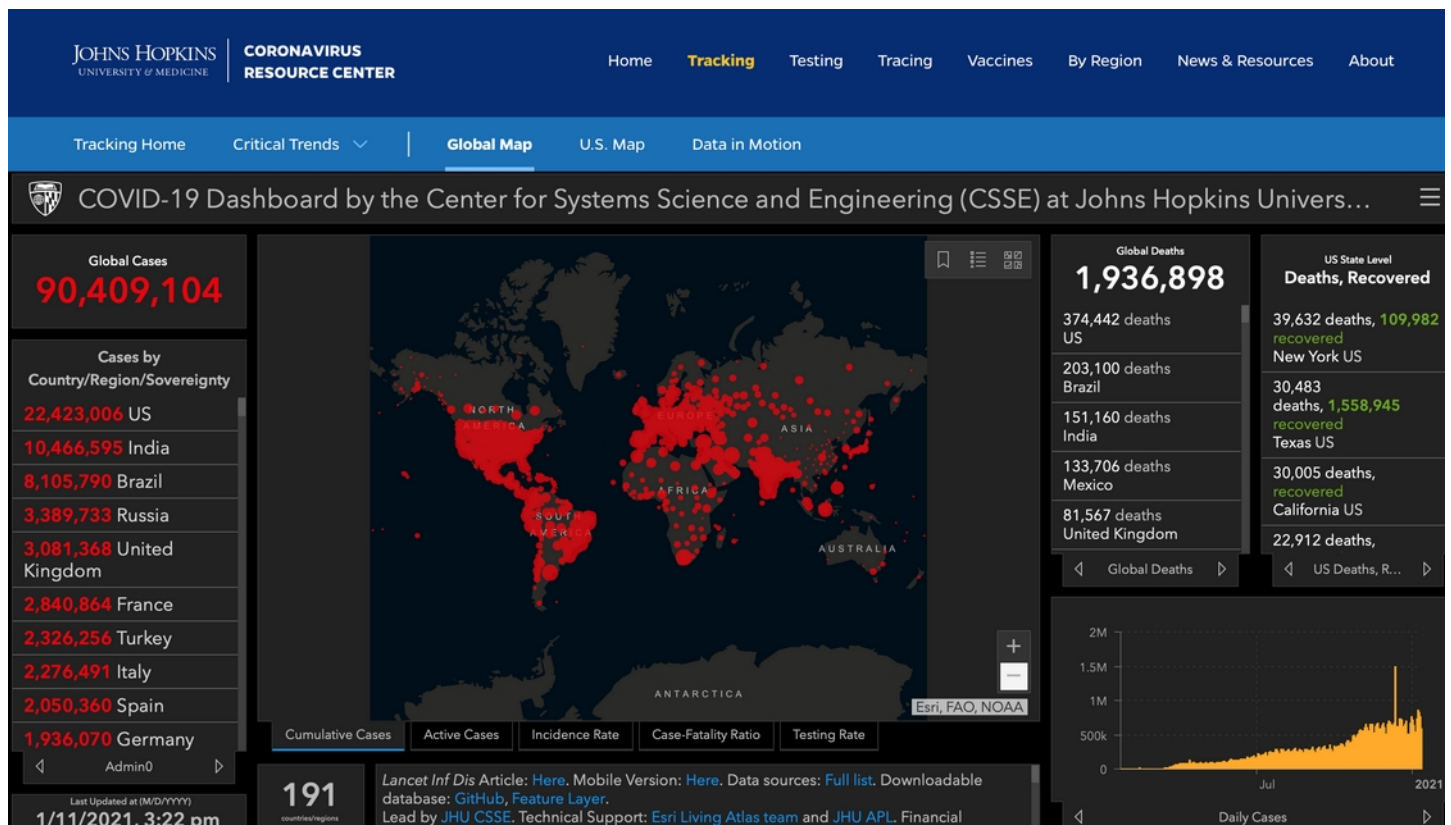


Figure 6. Johns Hopkins University COVID data dashboard (Johns Hopkins, 2020)

2.4. PERSONAL PROTECTIVE EQUIPMENT AND MEDICAL EQUIPMENT

From the beginning of the pandemic governments around the world struggled to cope with demand for PPE equipment for frontline healthcare workers. Healthcare professionals have called for greater input from designers in both the design of medical equipment and the physical environments that have been placed under immense pressure.

Stage 1 Reaction:

Masks and gowns: Many organisations, such as Burberry and Barbour switched production from their normal products to making masks, and non-surgical gowns (Burberry, 2020; Barbour, 2020).

Mullagh, L., Cooper, R., Thomas, L., Sacks, J., Jacobs, N. & Jones, P. L. (2021). Designing for a pandemic: towards recovery and resilience. *Strategic Design Research Journal*. Volume 14, number 01, January – April 2021. 161-174. DOI: 10.4013/sdrj.2020.141.14



Figure 6. Mask made by British Fashion Council (left) and homemade fabric mask (right)

During March and April, we found many examples of masks being made at home by individuals (Freeseewing, 2020) or by professionals with making skills who were furloughed, such as television costumiers (BBC, 2020a). This highlighted that during the early stages of the pandemic when people were socially and physically isolated, there was a desire to be involved in making things, with the materiality and processes that are positive for mental health. The use of platforms such as Facebook also enabled both amateur and professional makers to join together from a distance to help counter the issues with the lack of PPE (Murray, 2020).

Stage 2 Adaptation:

Accessibility and fashion: As we moved into the later stages, masks were produced using high quality fabrics from fashion designers, for example the British Fashion Council's 'Great British Designer Face Coverings' (British Fashion Council, 2020). Issues such as inclusivity and accessibility were also being recognised. The issue of masks being problematic for people with hearing issues who rely on seeing mouths to lip read began to emerge during this stage. A student developed a mask with a transparent mouth area, but this isn't a fully resolved design due to the need to see not only the mouth but the full chin area (Azzarello, 2020). A more mature design that tackles the issue with viewing the mouth is the 'HelloMask' (Houser, 2020) – a product created by scientists has been in development prior to the pandemic but will not be ready for full production until 2021.

At this stage we see provocations such as Ai Weiwei's mask series that comment on various aspects of the pandemic globally (Myers, 2020) and homegrown masks, meaning masks that could be made by individuals from materials that are effective and compostable (Sum Studio, 2020). As we move out of the adaptation stage, it is clear that masks will be required in the future and that the approach taken during the COVID-19 pandemic will not be adequate.

Ventilators: COVID-19 lifted the mechanical ventilator from obscurity. We came across a wide range of machines that were designed and produced by individuals using their own 3D printers at home (BBC, 2020b), girls in Afghanistan making ventilators from car parts (Haidare, 2020), to large global companies such as Dyson (Dyson, 2020) and the Formula One motor racing team (Mercedes Petronas, 2020).

The UK government launched their Ventilator Challenge in March 2020 and spent £454 million to incentivize private companies to innovate design and escalate production of ventilators (Kinder et al., 2020) before cancelling all design innovations in June 2020 (Tovey and Roberts, 2020). Dyson spent £21 million rapidly developing, prototyping and producing their machine in 30 days, only for the machines to not be required in the UK (Dyson, 2020). The Penlon Prima ES02 was created in response to the government's call. The proprietary

design lies in opposition to the open designs we gathered for the database, in particular those such as the OVSI ventilator system, a product of the Open Ventilator System Initiative (OVSI). This machine is a generative concept design, signalled by OVSI's commitment to the Open COVID Pledge (OVSI, 2020). The decentralised, open approach represented by OVSI aims to create 'inclusive innovation ecosystems ... to enable local manufacturing and maintenance of the OVSI ventilator systems' (OVSI, n.d).

3. DESIGNING TOWARDS RECOVERY AND RESILIENCE

Through understanding and learning from how design has contributed to the first two stages of the pandemic, we have developed principles to consider for the future stages of recovery and resilience. There has been a rapid refining of design interventions that become more elegant and considered as we move from the Reaction and Adaptation stages towards Recovery and Resilience. As countries reopen and embark upon a new way of operating, with localised outbreaks still occurring, vigilance is still fundamental. Designers and design researchers must carefully consider how we design for the latter two stages, Recovery and Resilience. From the findings presented above, we have identified key themes across all disciplines to consider how we might move forward into the Recovery and Resilience stages.

3.1. EFFECTIVE, CLEAR AND CONSISTENT COMMUNICATION

Throughout the pandemic we have seen different responses from governments and public health organisations in communicating new laws, health messages and visualizations of the impact of the virus. Some of the campaigns have been more successful than others (Kennedy, 2020; Moore, 2020) and demonstrate the importance of having a clearly defined strategy for graphic communication and data visualization. Designers are uniquely placed to work across disciplines in governments, healthcare and NGOs to develop clear communication strategies and data visualization due to their ability to absorb and disseminate complex data and information.

- Governments and organisations should prioritize design in communicating their messages.
- Designers, governments and NGOs should engage more with what the data means, how we make sense of it and how this is balanced with the aesthetic elements of visualizing complex, global epidemiological data.

3.2. DESIGN OF, WITH AND FOR COMMUNITY:

The global and collective experiences of the pandemic have highlighted various versions of 'being in it together', from governments and organisations, or through the grassroots community mutual aid groups that have emerged. People wanted to make things and have a physical connection with material and objects: everyone can be a designer, whether through the production of face masks or 3D printed products at home. This democratization, or opening up of design, demonstrates the importance of the making process and its potential for supporting positive mental health through unprecedented and stressful periods.

- Designers have a role in developing digital and analogue products and services to support individuals and communities to build resilience (economic, health, and social) into their lives.

3.3. EQUITABLE ACCESS TO AND ETHICAL DESIGN OF TECHNOLOGIES

Whilst the pandemic has seen a huge rise in the use of digital technologies, it has also highlighted issues of digital divide and inequitable access to internet and equipment such as smartphones and laptops (Berners-Lee, 2020). Also, the speed at which new technologies have been designed and deployed has led to complex issues relating to security, privacy and equitable access and potential to undermine public trust.

- it is vital that both analogue as well as digital systems are designed for those without digital access (Ada Lovelace Institute, 2020).
- it is vital that privacy and ethical principles are embedded by design from the outset (Morley et al. 2020).

3.4. DESIGNING COLLABORATIVELY

The sharing of designs for ventilators, associated spare parts, and face shields has demonstrated an economic imaginary that can be termed commonism. In short, commonism is a mode of production in which open generative systems create common products (also called commons) for decentralized peer governance (Dyer-Witheford, 2007). While we saw individuals sharing designs online, we also saw different examples of operation that included large organisations sharing their proprietary operations.

- Mobilization of design and implementation through commons will be important in ensuring resilience.

3.5. DESIGN AGILITY AND SPEED

Throughout the pandemic we have seen design and implementation of products and services occur at high speed. Layers of bureaucracy have been removed, as seen with the CDC in America, who relaxed strict testing protocols to get medical equipment into hospitals, or rapid passing of policy to enable the closure of large swathes of the economy, or writing social distancing regulations into law, 'speed is, of course, of the essence – but so is due diligence and due process' (Nature, 2020).

- Utilizing well tested design methods such as rapid prototyping or design sprints will enable multi-disciplinary teams to come together and work through complex issues.

3.6. DESIGNING SUSTAINABLY

The heavy use of disposable PPE in medical, social and domestic settings is unsustainable due its negative environmental impacts (Ip et al. 2020). New forms of PPE must improve human wellbeing whilst not diminishing planetary wellbeing. Disposable PPE equipment, particularly masks used in public settings, are increasingly being discarded after use, rather than being disposed of adequately. While homemade masks are often re-used and have greater potential to encourage sustainable behaviours, it is important for governments to begin to publicise the need for greater care in disposing of masks and for more sustainable alternatives to be developed, in line with the move towards circular economies.

- Designers can contribute to the development of sustainable PPE in two main ways:
 - through the design of PPE that demonstrates adequate environmental sustainability
 - through the design and disposal processes of equipment (particularly to members of

the public) and through the design of persuasive and informative communications about PPE and the need for re-usable equipment made from sustainable materials with robust disposal methods.

4. CONCLUSIONS AND FUTURE WORK

As a reactive piece of research, this paper explores a range of design interventions and propositions during the early stages of the pandemic. The authors continue to gather examples of design as the pandemic progresses and develop more nuanced and in-depth analysis to understand the potential strengths, issues and impacts of the interventions and propositions. We have demonstrated that during the pandemic a light has been shone upon many inequalities across societies and demonstrated the need to re-design at different scales, from the hyper-local to the societal level. There have been repeated calls to design a better society as a whole and we are mindful that design is only part of a solution in a crisis. Much of the work to enable recovery and build resilience is the responsibility of national governments and their collaboration with key agencies around the world. However, as demonstrated in this initial stage of this research, designers are able to connect across a wide range of disciplines and organisations to enable innovative and creative solutions.

Whilst we can present potential future scenarios for design, we are still experiencing profound uncertainty about the ways in which we emerge from the pandemic. What is evident, however, is a need for innovative, collaborative and cross-disciplinary approaches, which will result in future resilience. This places design in a strong position to be able to contribute to the ways in which we collectively move forward and build resilience at all scales of society. There is also a recognition globally that new ways of thinking at all scales, from the hyper-local to the global are required and this situation also presents opportunities to re-think and re-design societies from the ground up. This unique period in time offers an opportunity to collectively re-consider many aspects of our lives and to re-build in ways that are socially equitable, ethically responsible and more sustainable.

ACKNOWLEDGEMENTS

This research was carried out as part of the Beyond Imagination project at ImaginationLancaster funded by Research England Expanding, Excellence in England (E3).

REFERENCES

- Ackerman, E (2020) Autonomous Robots are Helping Kill Coronavirus in Hospitals, *IEEE Spectrum*, Retrieved 10 June, 2020, from <https://spectrum.ieee.org/autobot/robotics/medical-robots/autonomous-robots-are-helping-kill-coronavirus-in-hospitals>
- Azzarello, N (2020) Student creates transparent masks for the deaf and hard of hearing community. *Designboom*. Retrieved April 9, 2020, from <https://www.designboom.com/design/student-creates-transparent-masks-deaf-hard-of-hearing-04-08-2020/>
- Barbour (2020) *Barbour Service Update*, Retrieved June 10, 2020, from <https://uk.burberry.com/burberry-supports-the-fight-against-covid-19/>
- BBC (2020a) *Coronavirus: TV costume makers create scrubs for NHS Staff*, Retrieved April 15, 2020, from <https://www.bbc.co.uk/news/av/uk-wales-52273528/coronavirus-tv-costume-makers-create-scrubs-for-nhs-staff>
- BBC (2020b) *3D Printer Owners Rally to create NHS face masks*, Retrieved April 1, 2020, from <https://www.bbc.co.uk/news/technology-52111522>
- Berners-Lee (2020), COVID-19 makes it clearer than ever: access to the internet should be a universal right. *The Guardian*. Retrieved June 5, 2020, from

<https://www.theguardian.com/commentisfree/2020/jun/04/covid-19-internet-universal-right-lockdown-online>

- Block, I (2020) Google's Wing drones deliver essentials during coronavirus pandemic. *Dezeen*. Retrieved June 20, 2020, from <https://www.dezeen.com/2020/04/15/google-wing-drone-delivery-coronavirus-virginia/%20>
- BMJ (2020); 371:m4857. DOI: <https://doi.org/10.1136/bmj.m4857>
- British Fashion Council (2020) Great British Designer Face Coverings, Retrieved June 10, 2020, from <https://www.britishfashioncouncil.co.uk/About/Great-British-Designer-Face-Coverings>
- Burberry (2020) Burberry supports the fight against COVID-19, Retrieved June 20, 2020, from <https://uk.burberry.com/burberry-supports-the-fight-against-covid-19/>
- COMARCH, (2020) Quarantined Sofia residents to receive Comarch LifeWristbands, Retrieved 30 April, 2020, from <https://www.comarch.com/press-center/news/corporate/quarantined-sofia-residents-to-receive-comarch-lifewristbands/>
- Cureton, P (2020a) Back to the future "Roads? Where we're going we don't need ... roads!" *About Manchester*. Retrieved June 6, 2020, from <https://aboutmanchester.co.uk/back-to-the-future-roads-where-were-going-we-dont-need-roads/>
- Cureton, P (2020b) How drones and aerial vehicles could change cities. *The Conversation*, Retrieved July 8, 2020, from <https://theconversation.com/how-drones-and-aerial-vehicles-could-change-cities-140907>
- Dyer-Witthford, N. (2007). Commonism. *Turbulence*, 1(1). Retrieved June 8, 2020, from <http://www.turbulence.org.uk/turbulence-1/commonism/index.html>
- Dyson (2020) *Ventilator Update*, Retrieved June 20, 2020, from <https://www.dyson.co.uk/newsroom/overview/update/ventilator-update.html>
- Fouquet, H; Sebag, G (2020) French Covid-19 Drones Grounded After Privacy Complaint. *Bloomberg*. Retrieved 20 June, 2020, from <https://www.bloomberg.com/news/articles/2020-05-18/paris-police-drones-banned-from-spying-on-virus-violators>
- Freeseewing (2020) Calling all makers: Here's a 1-page PDF facemask pattern; now go make some and help beat this thing, Retrieved June 6, 2020, from <https://freeseewing.org/blog/facemask-frenzy/>
- Gonzalez, S (2020) For School of Drama, mask-making takes on new meaning and urgency, Retrieved April 14, 2020, from <https://news.yale.edu/2020/04/13/school-drama-mask-making-takes-new-meaning-and-urgency>
- Haidare, S (2020) Coronavirus: Afghan girls make ventilators out of car parts, *BBC*. Retrieved July 1, 2020, from <https://www.bbc.co.uk/news/world-asia-52738668>
- Houser, K (2020) *Fully see-through face mask ready for mass production*, Retrieved June 11, 2020, from <https://www.freethink.com/articles/see-through-face-mask>
- Ivey-Williams, K; Allers, M; Dub, S (2020) *Designing the GOV.UK coronavirus page*, Retrieved June 7, 2020, from <https://designnotes.blog.gov.uk/2020/06/08/designing-the-gov-uk-coronavirus-page>
- Ip, V; Özelsel, T; Sondekoppam, R; Tsui, B. (2012). *COVID-19 Pandemic: Is Sustainability the Answer to Personal Protective Equipment (PPE) Shortages?* Retrieved June 10, 2020, from <https://www.asra.com/page/2934/covid-19-pandemic-is-sustainability-the-answer-to-personal-protective-equipment? zs=OS9cX& zl=AT162>
- Johns Hopkins University (2020) Global COVID-19 Data and Visualizations, Retrieved July 1, 2020, from <https://coronavirus.jhu.edu>
- Kennedy, H (2020) *Simple Data Visualizations have become key to communicating about the COVID-19 pandemic*, Retrieved 10 May, 2020, from <https://blogs.lse.ac.uk/impactofsocialsciences/2020/05/04/simple-data-visualisations-have-become-key-to-communicating-about-the-covid-19-pandemic-but-we-know-little-about-their-impact/>
- Kinder, T., Foster, P., & Pooler, M. (2020). *Ventilator challenge to cost government £450m despite cancellations*. Retrieved May 20, 2020, from <https://www.ft.com/content/8df85bb4-4e2e-41f3-bb51-c7d046d23455>
- Lindley, J; Coulton, P; Cooper, R "Informed by design," *Living in the Internet of Things: Cybersecurity of the IoT - 2018*, London, 2018, pp. 1-12. DOI: [10.1049/cp.2018.0022](https://doi.org/10.1049/cp.2018.0022)
- Liu, Y (2020) *China adapts surveying, mapping, delivery drones*, Retrieved June 3, 2020, from <https://www.scmp.com/business/china-business/article/3064986/china-adapts-surveying-mapping-delivery-drones-task>
- McCandless, D (2020) *Information is Beautiful*, Retrieved April 20, 2020, from <https://informationisbeautiful.net>

- Mercedes Petronas (2020) Designs for Life-saving Breathing aid to be Made Freely Available, Retrieved April 30, 2020, from <https://www.mercedesamgf1.com/en/news/2020/04/ucl-uclh-f1-project-pitlane-start-delivery-breathing-aids-nhs-hospitals/>
- Meyer, A (1982) Adapting to Environmental Jolts, *Administrative Science Quarterly*, 27 (4) pp.515-537. DOI: [10.2307/2392528](https://doi.org/10.2307/2392528)
- Moore, R (2020) The UK Government Coronavirus Strategy: Shoddy by design? *The Guardian*. Retrieved June 14, 2020, from <https://www.theguardian.com/artanddesign/2020/jun/14/the-uks-government-coronavirus-strategy-shoddy-by-design>
- Morley, J.C; Taddeo, M; Floridi, L (2020) Ethical guidelines for COVID-19 tracing apps. *Nature* 582, 29-31 DOI: [10.1038/d41586-020-01578-0](https://doi.org/10.1038/d41586-020-01578-0)
- Murray, J (2020) Volunteers stitch together to make scrubs for the NHS, *The Guardian*. Retrieved April 14, 2020, from <https://www.theguardian.com/world/2020/apr/13/volunteers-stitch-together-make-scrubs-for-nhs>
- Myers, L (2020) *Ai Weiwei designs face masks for charity*, Retrieved May 20, 2020, from <https://www.designboom.com/art/ai-weiwei-designs-coronavirus-masks-for-charity-middle-finger-05-28-2020/>
- Nature (2020) Covid-19 digital apps need due diligence, *The International journal of science, Nature*, Vol.580 30th April 2020, Retrieved June 15, 2020 from <https://media.nature.com/original/magazine-assets/d41586-020-01264-1/d41586-020-01264-1.pdf>
- Neira, J (2020a) *Singapore deploys dog robots to remind people of safe distancing measures*, Retrieved June 15, 2020, from <https://www.designboom.com/technology/singapore-deploys-dog-robots-safe-distancing-measures-05-08-2020/>
- New Zealand Government (2020) Unite for Recovery, Retrieved June 30, 2020, from <https://uniteforrecovery.govt.nz/updates-and-resources/posters/>
- OVSI. (n.d.). Mission - Open Ventilator System Initiative. OVSI - Open Ventilator System Initiative. Retrieved June 29, 2020, from <https://ovsi.org/mission>
- Privacy International (2020a) Tracking the Global Response to COVID-19 Retrieved July 1, 2020, from <https://privacyinternational.org/examples/tracking-global-response-covid-19>
- Privacy International (2020b) Hangzhou plans permanent role for Corona surveillance app, Retrieved June 30, 2020, from <https://privacyinternational.org/examples/3886/hangzhou-plans-permanent-role-coronavirus-surveillance-app>
- Spears, T (2020) *Boston Dynamics spot robot dog helps doctors treat COVID-19 patients*, Retrieved June 15, 2020, from <https://www.designboom.com/technology/boston-dynamics-spot-robot-dog-doctors-covid-19-04-24-2020/>
- Stokel-Walker, C (2020) Smartphone contact-tracing technology has played a role in easing lockdown in China, *BBC*. Retrieved June 6, 2020, from <https://www.bbc.com/future/article/20200415-covid-19-could-bluetooth-contact-tracing-end-lockdown-early>
- Sum Studio (2020) Xylinym Mask, Retrieved May 15, 2020, from <https://www.designboom.com/design/sum-studio-home-grown-cellulose-mask-biodesign-05-13-2020/>
- Tovey, A., & Roberts, L. (2020, June 10). All new ventilator models abandoned by ministers. *The Telegraph*. Retrieved June 27, 2020, from <https://www.telegraph.co.uk/business/2020/06/10/new-ventilator-models-abandoned-ministers/>
- TraceTogether (2020) Singapore's Track and Trace mobile application, Retrieved June 1, 2020, from <https://www.tracetogogether.gov.sg>
- Veale, M; Binns, R; Ausloos, J (2018) When data protection by design and data subject rights clash; *International Data Privacy Law*, 8 (2), PP 105-123. DOI: [10.1093/idpl/ipy002](https://doi.org/10.1093/idpl/ipy002)
- Venkataramakrishnan, S (2020) *Researchers turn to wearable tech in race to track COVID-19*, *Financial Times*. Retrieved June 11, 2020, from <https://www.ft.com/content/f13106bd-dc49-455e-ad9c-5aec256f9aa8>
- WHO (2020a) Global call out to Creatives, Retrieved May 10, 2020, from <https://www.talenthouse.com/i/united-nations-global-call-out-to-creatives-help-stop-the-spread-of-covid-19>
- WHO (2020b) WHO Timeline- COVIC-19, Retrieved December 29, 2020, from: <https://www.who.int/publications/m/item/weekly-epidemiological-update---29-december-2020>
- Wong, H (2020) "Government needs to make people care": designers on coronavirus communications, Retrieved April 10, 2020, from <https://www.designweek.co.uk/issues/23-29-march-2020/coronavirus-communications-government/>